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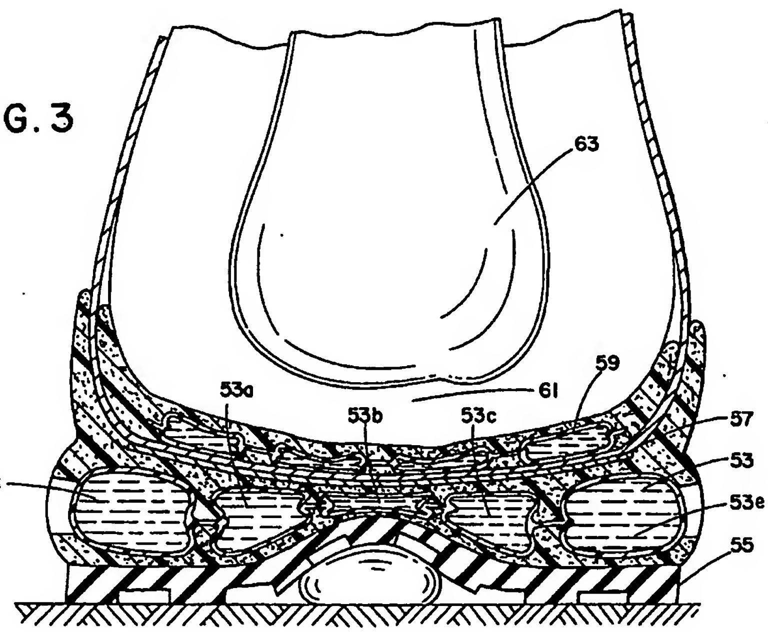
(54) **Article of footwear having multiple fluid containing members**

(57) An article of footwear includes one or more first fluid containing cushion devices (59) in direct or elastomeric load transmitting contact with a foot to provide superior comfort. One or more second, preferably thicker, fluid containing cushion devices (53) are positioned in a load transmitting portion of the sole, between the foot and ground engaging surface of the footwear. The first cushion device(s) at least partially overlap a portion of the second cushioning device(s) and the two cushion devices are at least partially separated in any overlapping areas by a load distributing element (57).

FIG.3



EP 0 714 613 A2

Description

Field of the Invention

This invention relates to articles of footwear having improved cushioning, comfort and stability. Particularly, this invention relates to articles of footwear that include cushioning devices which provide superior comfort to a wearer and provide superior performance under high loading conditions.

Background of the Invention

Articles of footwear have long been studied and redesigned to achieve enhanced comfort and performance. In this regard, and particularly in athletic shoes, primary concerns include the ability to provide the foot with a comfortable environment and to mitigate the shock or impact experienced when the shoe and, accordingly the foot and lower leg, impact the ground or floor. These forces are particularly significant during running and jumping. For example, a jogger landing on four or five square inches of the heel is estimated to absorb an impact force of about three to four times the weight of the jogger. Accordingly, a jogger of 180 pounds may create an approximate force of 720 pounds of shock on the heel landing area. Since each heel could impact the ground about 800 times per mile, it is easy to see the necessity of a shock absorbing mechanism in footwear.

In addition to a shoe absorbing intense and repeated impact, the criticality of comfort is readily understood by everyone who wears shoes. In fact, comfort in athletic shoes is known to effect the wearer's psychological state, and therefore, his or her performance, muscular efficiency, energy consumption, and the athlete's ability to train and compete.

A variety of elastomeric materials, including natural rubber, polymerized and copolymerized elastomers, and synthetic rubbers have been used in shoe construction to absorb these forces. However, these elastomeric materials suffer degradation from repeated use and have relatively poor energy transfer efficiency characteristics. Accordingly, the industry has searched for alternative means of foot cushioning.

In this search, pneumatic cushioning devices have long been studied. For example, U.S. Patent 259,092 (1882) demonstrates a very early pneumatic sole. Notwithstanding the long search, pneumatic cushioning devices failed for nearly a century and for a variety of reasons to achieve commercial success. In fact, until the inventions described in U.S. Patents 4,183,156 and 4,219,945 were made, the art lacked the technological know-how to make pneumatic cushioning in shoes commercially successful. The inventions described in these patents revolutionized shoe design and the athletic footwear market place, having been incorporated into at least 200 million shoes sold worldwide.

Following this initial success of pneumatic cushioning, several attempts to improve these systems have been made. U.S. Patent No. 4,506,460, for example, discloses a moderator device which functions in combination with either elastomeric or pneumatic cushioning elements. The moderator is used to absorb, redistribute, store and return energy. U.S. Patent No. 5,083,361 describes a shoe including a stacked air chamber arrangement. In this design, the air chambers are constructed with an outer barrier layer of elastomeric material with drop-linked fabric to average stress of the chambers and maintain stability. It is also suggested to inflate the top chamber to a lower pressure in order to provide initial contact softness.

Taiwanese Application No. 75100322 discloses an outboard double deck air cushion where the peripheral air chambers in the top unit and the peripheral air chambers in the bottom unit are in fluid communication. The central air chambers of the top air cushion and those of the bottom air cushion are also in fluid communication. This design is intended to provide an air insert which continues to support the wearer after being punctured. For that purpose, the design includes a piercing proof sheet material such as a light metal between the first and second air cushions to prevent puncture of the upper cushion. However, this design, by allowing fluid communication between the top and bottom air cushions, may be unstable as a result of rapid, almost instantaneous, dispersion of air pressure under a load applied to localized areas. More particularly, this design appears to act more like a thick single cushion insert than two separate units. In fact, it is believed that this design leads to "bottoming out" of heavily loaded chambers and the simultaneous ballooning of unloaded chambers, causing instability when an uneven force is applied to the plantar surface of the foot or the outsole of the shoe. This instability termed herein a "tennis ball" effect appears to be particularly true when the cushions total more than 0.800 inches in thickness. Accordingly, this design presents an injury risk and fails to provide the advantage of superior comfort and superior performance in an article of footwear.

As is apparent from the above description of the art, a need exists for a cushioning system which provides both the comfort and performance benefits of fluid cushioning. This invention provides a means to achieve several very important goals; superior comfort in a shoe in combination with superior technical performance and lightness of weight.

Summary of the Invention

In accordance with the purpose of the invention as embodied and broadly described herein, the article of footwear of this invention comprises a shoe upper shaped to envelop and cushion the foot. The upper is attached to a sole having a ground engaging portion. A first sealed elastomeric member containing a fluid is positioned in the article of footwear between at least a portion of the foot and the ground engaging portion of the sole. A second sealed elastomeric member contain-

ing a fluid is positioned between the foot and the ground engaging portion of the sole, with at least a portion of the first member overlapping the second member. A load distributing element is positioned between the first and second members, intermediate at least a portion of the overlapping region of the members.

The first member of this shoe is preferably located within the shoe's foot constraining envelope, and is termed "inboard" for purposes of this disclosure. This location provides exceptional point-of-sale appeal, because the fluid containing cushion insert is in direct elastomeric proximity with the plantar surface of the foot, providing the wearer with a clear "riding-on-air" sensation (in the case of air filled inserts). Preferably, the second elastomeric member is located in the sole of the shoe, exterior and below the shoe upper envelope encasing the foot, and is termed "outboard". This cushion is preferably designed to absorb and beneficially redistribute, store and return significant impact forces.

Accordingly, an article of footwear is described with a fluid containing elastomeric cushioning device adjacent the foot and a fluid containing elastomeric cushioning device more proximate the ground engaging surface of the shoe. In certain embodiments, the fluid containing cushioning device nearer the ground engaging surface of the shoe may be constructed with one side functioning as the ground engaging surface of the shoe.

A load distributing element is located between the two cushioning devices to prevent painful and destabilizing localized forces and to facilitate load dispersion across the cushioning devices, increasing their effectiveness. In this preferred design, the two cushioning devices respectively provide comfort and performance and, in fact, overall superior cushioning may occur. Therefore, this invention advantageously provides a new and improved article of footwear providing both superior comfort and performance.

The article of footwear according to the invention comprises an upper shaped to envelop a foot and a sole secured to said upper, said sole having at least a ground engaging portion, a first sealed barrier member of elastomeric material containing a fluid positioned between at least a portion of said foot and said ground engaging portion of said sole, a second sealed barrier member of elastomeric material containing a fluid positioned between at least a portion of said foot and said ground engaging portion of said sole, said first sealed member at least partially overlapping said second sealed member, and a load distributing element to redistribute forces located between at least a portion of said overlapping region of said first and second members.

Preferably, said elastomeric material of said first and second members further comprises polyurethane.

Preferably, said first member is further comprised of a plurality of interconnecting chambers.

Preferably, said second member is further comprised of a plurality of interconnecting chambers.

Preferably, said second member is at least partially encapsulated in an elastomeric material.

Preferably, said first and second members are positioned under substantially the entire plantar's surface of said foot.

Preferably, said first member is positioned only under a heel portion of said foot.

Preferably, said second member is positioned only under a heel portion of said foot.

Preferably, at least one of said members comprises at least two separate inserts, a first of said inserts under a heel area of said foot and a second of said inserts under a ball-of-the-foot area.

Preferably, said first member has a thickness of less than 0.350 inches.

Preferably, said first member has a thickness of less than 0.250 inches.

Preferably, said second member has a thickness of greater than 0.400 inches.

Preferably, the article further comprises a sockliner, wherein said first member forms at least a portion of said sockliner.

Preferably, the fluid in at least one of said members is compressible.

Preferably, the fluid of said first member is compressible and the fluid of said second member is incompressible.

Preferably, the fluid of said second member is compressible.

Preferably, the fluid of said first and second members is compressible.

Preferably, said first and second members have a gage pressure greater than 0 and said second member has a gage pressure greater than said first member.

Preferably, said first member has a gage pressure of between 0 and 20 psi and said second member has a gage pressure of between about 15 and 50 psi.

Preferably, the fluid in at least one of said members comprises a mixture of air and a gas selected from the group consisting of hexafluoroethane, sulfur hexafluoride and mixtures thereof.

Preferably, the fluid in at least one of said members is selected from the group consisting of water, semi-gel liquids, oil, grease, soft or liquid wax, glycerine, soaps, silicone, corn syrup, rheopexic liquids, and thixotropic liquids.

Preferably, at least one of said members is inflatable by a valve mechanism and external fluid source.

Preferably, at least one of said members is adjustable by a valve mechanism and external fluid source.

Preferably, at least one of said members is inflatable by a permanently sealable fluid transport system and external fluid source.

Preferably, said load distributing element is comprised of a flexible and resilient material.

Preferably, said load distributing element has a modulus of elasticity between about 250,000 psi and about 1,000,000 psi.

Preferably, said load distributing element comprises a medial leg, a lateral leg and a heel portion interconnecting said two legs, each leg and heel portion being

relatively flat, said medial and lateral legs located on each side of a calcaneus having a fat pad, said load distributing element underlying at least 40% of the fat pad of said foot while the heel portion is located nominally behind the calcaneus, said load distributing element having the ability to deflect under said applied load and return to its original shape upon removal of the applied load.

Preferably, said load distributing element further comprises a relatively flat member underlying at least the metatarsals.

Preferably, said load distributing element comprises a substantially flat perforated member underlying substantially the whole of said foot.

Preferably, said load distributing element is comprised of a material selected from the group consisting of wire or plastic filament mesh, Robus board, Texon board, high modulus plastic, fiber reinforced composites, cement or adhesive reinforced fabric or leather, and mixtures thereof.

Preferably, said ground engaging portion is formed as an integral part of said second member.

The invention further provides for a structure adapted to form part of a shoe comprising a first fluid containing cushioning device at a first pressure, said first device in a load transmitting position intermediate a foot and a ground engaging portion of said shoe, a second fluid containing cushioning device at a second and higher pressure, said second device in a load transmitting position intermediate at least a portion of said first device and a ground engaging portion of said shoe, a load distributing element to redistribute force in a load transmitting position intermediate at least a portion of the load transmitting area intermediate said first and second devices.

The present invention further provides a structure adapted to form part of a shoe comprising a first fluid containing cushioning device less than 0.350 inches in thickness, said first device in a load transmitting position intermediate a foot and a ground engaging portion of said shoe, a second fluid containing cushioning device greater than 0.400 inches in thickness, said second device in a load transmitting position intermediate at least a portion of said first device and said ground engaging portion of said shoe, a load distributing element to redistribute force in a load transmitting position intermediate at least a portion of the load transmitting area intermediate of said first and second devices.

Preferably, said first fluid containing device is less than about 0.250 inches in thickness.

Preferably, said first fluid containing device forms at least a portion of a sockliner.

The present invention further provides an article of footwear comprising an envelope to hold a foot, an inboard fluid filled cushioning device in a load transmitting position, an outboard fluid filled cushioning device in a load transmitting position, and a load distributing element to redistribute force positioned at least partially intermediate an overlapping region of said cushioning devices.

Preferably, said article further comprises a sockliner wherein said inboard device forms at least a portion of said sockliner.

The present invention further provides an article of footwear comprising an upper shaped to envelop a foot and a sole secured to said upper, said sole having at least a ground engaging portion; an outboard sealed barrier member of elastomeric material having a thickness of greater than 0.400 inches; an inboard sealed barrier member of elastomeric material having a thickness of less than about 0.350 inches; said inboard member overlapping at least a region of said outboard member and a load distributing member located between at least a portion of said overlapping region.

Preferably, said outboard member contains a compressible fluid and has a gage pressure of between about 15 and 50 psi.

Preferably, said inboard member contains a compressible fluid and has a gage pressure of between about 0 and 20 psi.

The present invention further provides an article of footwear comprising an upper shaped to envelop a foot and a sole secured to said upper, said sole having at least a ground engaging portion; a first sealed barrier member of elastomeric material containing a fluid positioned between at least a portion of said foot and said ground engaging portion of said sole, a second sealed barrier member of elastomeric material containing a fluid positioned between at least a portion of said foot and said ground engaging portion of said sole at least partially overlapping said first sealed member, a load distributing element to redistribute force located between at least a portion of said overlapping region of said first and second members, and wherein the combined thickness of said fluid filled members in said overlapping region is in excess of 0.800 inches.

Preferably, at least one of said members contains a pressurized fluid and has a gage pressure greater than 0 psi.

Brief Description of the Drawings

The invention consists of the novel parts, construction, arrangements, combinations and improvements shown and described. The accompanying drawings, which are incorporated and constitute a part of the specification illustrate the invention and, together with the description, serve to explain the principles of the invention.

Of the drawings:

Figure 1 is a side elevation view of a shoe incorporating a preferred embodiment of the invention;

Figure 2 is a diagrammatic view, partly in section and partly in elevation taken on line A-A of Fig. 1, under a standing load condition;

Figure 3 is a diagrammatic view similar to Figure 2, partly in section and partly in elevation, of a preferred embodiment shoe structure incorporating cushioning devices containing compressible fluids and the load distributing element of the current invention under a moderate load;

Figure 4 is a diagrammatic view similar to Figure 2, partly in section and partly in elevation, of a preferred embodiment shoe structure incorporating a cushioning device containing an incompressible fluid and the load distributing element of the current invention under a moderate load;

Figure 5 is a diagrammatic view similar to Figures 3 and 4, partly in section and partly in elevation, of a prior art shoe structure incorporating two outboard cushion devices in fluid communication under a moderate load;

Figure 6 is a graphical representation illustrating estimated load versus deflection and the associated comfort versus performance of a shoe including a preferred embodiment cushioning system;

Figure 7 is a perspective view illustrating the unassembled parts of a preferred embodiment shoe;

Figure 8 is a diagrammatic view partly in section and partly in elevation similar to Fig. 2, of an alternative embodiment of the inventive shoe; and

Figure's 9A, 9B, 9C, and 9D are top views of exemplary load distributing elements.

Detailed Description of the Invention

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings. While the invention will be described in connection with the preferred embodiment, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention defied by the appended claims.

Referring now to Figures 1 and 2, it may be seen that an article of footwear having an inboard cushioning device primarily for comfort and an outboard cushioning device primarily for absorbing high load is provided. The footwear includes an upper **1** generally made of leather, nylon or other material or other combination of materials known to those of ordinary skill in the art. Positioned within the upper **1** is a sockliner **2** comprised of an elastomeric material such as foam **3**, encapsulating at least the upper surface of an inboard fluid containing cushioning device **5**. Accordingly, the calcaneus bone **7** and fat pad **8** are in elastomeric contact with the inboard cushioning device **5**.

The upper **1** is formed by any means acceptable to those of skill in the art such as, but not limited to, boardlasting or stitchlasting. The upper shown herein is appropriate for athletic shoes, however, sandal uppers and boot uppers are equally suited for combinations with the sole construction of this invention. The sole **9** is secured to the upper by glue and/or stitching, or other techniques well known to those skilled in the art. The preferred sole **9** comprises a midsole portion **13** and outsole portion **15** contacting the ground. The outsole portion **15** is generally textured with tread or studs **17** to facilitate good frictional engagement with the ground or a floor surface. Midsole **13** is comprised of a foam **21** encapsulated outboard fluid containing cushioning device **23**, visible through view holes **19**. As is apparent, a load distributing element **24** is positioned intermediate the two cushioning devices **5** and **23**.

A variety of cushioning devices and designs can be incorporated into this invention. In addition to the cushioning devices **5** and **23**, other preferred cushioning devices, their manner of production, assembly, and incorporation into footwear are described in U.S. Patents 3,005,272; 3,685,176; 3,760,056; 4,183,156; 4,217,705; 4,219,945; 4,271,606; 4,287,250; 4,297,797; 4,340,626; 4,370,754; 4,471,538; 4,486,901; 4,506,460; 4,724,627; 4,779,359; 4,817,304; 4,829,682; 4,864,737; 4,864,738; 4,906,502; 4,936,029; 5,042,176; 5,083,361; 5,097,607; 5,155,927; 5,228,217; 5,235,715; 5,245,766; 5,283,963; and 5,315,769 each of which is herein incorporated by reference.

As will be understood by one of ordinary skill in the art, the cushioning inserts may be positioned as desired under the foot. Particularly preferred areas are under the heel, the longitudinal arch and under the metatarsals (i.e., the ball-of-the-foot). Included within the meaning of an inboard or outboard, first or second, cushioning device as used throughout this description are cushions comprised of multiple, separate and/or distinct cushioning peds. For example, the outboard cushioning device proximate the ground engaging surface of the shoe may be comprised of a heel ped and a separate toe ped. Accordingly, the heel and toe peds, although not connected, together are referred to herein as one outboard cushioning device.

Preferably, the elastomeric material of the cushioning devices is selected from the following: polyurethane, polyester elastomer; fluoroelastomer; chlorinated polyethylene, polyvinylchloride; chlorosulfinated polyethylene; polyethylene/ethylene vinyl acetate copolymer; neoprene; butadiene acrylonitrile rubber; butadiene styrene rubber; ethylene propylene polymer; natural rubber; high strength silicone rubber; low density polyethylene; adduct rubber; sulfide rubber; methyl rubber; and thermoplastic rubber. One material that is particularly preferred is polyurethane film.

When a compressible fluid is desired, the elastomeric members are preferably filled with a compressible "supergas" comprising a non-polar large molecule gas or gases and air. These fall within the self-inflating, via diffusion pumping technology, of the above described prior patents. Gases which have been found suitable are as follows: hexafluoroethane; sulfur hexafluoride; perfluoro propane; perfluorobutane; perfluoropentane; per-

fluorohexane; perfluoroheptane; octafluorocyclobutane; perfluorocylobutane; hexafluoropropylene; tetrafluoromethane; monochloropentafluoroethane; 1,2-dichlorotetra-fluoroethane; 1,1,2-trichloro-1,2,2-trifluoroethane; chlorotrifluoroethylene; bromotrifluoromethane; and monochlorotrifluoromethane. The two most desirable gases for use in the members are hexafluoroethane and sulfur hexafluoride. Of course, contemplated within the scope of this invention are cushioning devices filled with other compressible fluids in combination with foams and mechanically inflated gas (including air) cushioning devices.

Alternatively, the elastomeric member can be filled with a incompressible fluid which is generally a liquid or gel. The preferred characteristics of the fluid are that it is non-toxic, preferably odor free, it does not freeze at temperatures to which the article of footwear is normally exposed, and it possesses an acceptable viscosity, for example, 1,000 to 1,250 centistokes. Incompressible fluids such as water; semi-gel liquids; oil; grease; soft or liquid wax; glycerine; soft soaps; silicone; rheopexic fluids; thixotropic fluids; and corn syrups exemplify but are not limiting examples of acceptable fluids. The fluid can also be treated with a bactericide or anti-fungal agent for their obvious benefits.

In addition, cushioning members utilizing incompressible fluids have also been designed to include the combination of a particulate material and a liquid to tailor the viscosity and cushioning characteristics. Phenolic resin particles, silica and ceramic spheres are examples of particulate material which may be utilized. Of course, at least two cushioning devices of the invention can each be filled with different materials, i.e. air in the inboard cushion and viscous silicone oil in the outboard cushion. In addition, the cushioning devices may be filled with a combination of incompressible fluid and compressible fluid.

The article of footwear in Figure 2 is now referred to for illustration of certain properties of the invention. Particularly, a fluid containing inboard cushioning device is positioned to provide substantially uninterrupted elastic cushioning to the foot within the foot constraining envelope of the shoe. This provides the article of footwear user with a "riding-on-air" feel (when air/gas filled) and the associated high degree of comfort. A generally thicker (defined along the axis between the foot and ground engaging surface of the shoe) and generally higher pressurized fluid containing outboard cushioning device (if a compressible fluid cushioning device is utilized) is positioned in the midsole. This thicker, higher pressure outboard cushioning device primarily functions to absorb and distribute high load conditions encountered during running, jumping, stopping and blocking.

The following examples illustrated by Figures 3, 4, and 5 comparatively demonstrate the useful and beneficial results achieved by this invention. Figure 3 illustrates the footwear of the present invention under a moderate load. Moreover, Figure 3 illustrates the load distribution mechanism of the current invention when uneven loading is applied. As illustrated, the foam encapsulated outboard performance oriented cushioning device **53** is compressed to absorb impact of the shoe with the ground having an uneven surface (a rock). Compression of individual chambers **53a**, **53b** and **53c** is more significant as a result of the added stresses to the outsole **55** at the point of engagement with the rock. However, the load distributing element **57** prevents significant localized vertical deflection, effecting a horizontal force distribution of the high localized load, transferring the forces of the individual chambers (**53a**, **53b** and **53c**) across a large surface area of the inboard downward deflecting comfort insert **59**. Accordingly, the load is more equally distributed across the fat pad of the heel **61**, reducing the possibility of instability or a stone bruise to the heel of the foot by the outboard cushioning chambers **53a**, **53b**, and **53c** pushed upward by the rock. In addition, the shoe design more evenly distributes the force as the gas moves from chambers **53a**, **53b** and **53c** into chambers **53d** and **53e**, providing greater comfort and less jarring to the calcaneus **63** and the remainder of the lower leg and body.

Under a light load, the inboard insert **59** supported on an appropriate load distributing element **57** provides a perceived, dynamic, instantaneous, plantar foot shape conforming "riding-on-air", comfort and support for the foot. Under higher loads, the inboard cushioning device **59** deflects and cushions in a downward motion against the load distributing element **57** through its full range of cushioning support from the maximum thickness at an unloaded condition to a bottoming out condition. Coincidentally, additional deformation of outboard device **53** occurs and higher shock loads are absorbed. The load distributing element provides a load supportive, flexible, dynamic plane, which is either flat or anatomically contoured. This plane separates the normally downward load deflection and cushioned forces of the foot all or in part, from the upward vectored shock forces absorbed and cushioned substantially by the outboard cushioning device, emanating from the impact of the shoe outsole with the floor or ground.

Referring now to Figure 4, the footwear of the present invention under a moderate load is demonstrated wherein the outboard cushioning device **153** is a incompressible fluid design. In this design, the outboard cushioning device **153** is encapsulated within midsole **155**. Cushioning device **153** is flexibly secured at its top and bottom surfaces with an elastomeric encapsulating foam **158**. Under a moderate load with a uneven force distribution caused by the rock, incompressible fluid **151** is forced from the central region of cushioning device **153** flowing in the direction of arrows **152** toward the periphery **156** of the cushioning device. Fluid flow causes an increased pressure at the periphery **156** of the cushioning device and a bulging of the elastomeric cushioning device in this side wall area. Accordingly, shock forces are absorbed by the elastomeric action of the peripheral chamber walls **156** and the forced fluid flow. As in Figure 3, load distributing element **157** disperses uneven forces

caused by the rock more uniformly across the inboard cushioning member **159**. Therefore, the fat pad **161** and calcaneus **163** are not subject to instability or a stone bruise. Although Figure 4 demonstrates a outboard incompressible fluid cushioning device and an inboard compressible fluid cushioning device, these elements could be reversed or incompressible cushioning units could be utilized both inboard and outboard.

While the outboard incompressible fluid cushioning device is shown as a single unit, including an adjacent cavity for expansion, a variety of designs can clearly be utilized in the present invention. For example, multichambered units having fluid connections between at least some of the units can be used. In addition, flow restrictors may be utilized between the chambers to tailor the fluid flow to meet required cushioning demands. Other designs include a heel chamber connected via channels to a chamber under the metatarsals causing fluid flow toward the forward chamber on heel strike and rearward during toe off. Particularly preferred incompressible fluid containing designs include a small amount of compressible fluid in the chamber or a connected chamber containing predominantly incompressible fluid which allows compression within the chamber to occur in addition to expansion of the elastomeric cushioning walls when a load is applied.

The same moderate load conditions are demonstrated in Figure 5, however, both upper and lower cushioning devices are outboard and are in fluid communication (not shown) with one another. This illustration demonstrates the importance of having fluid independence of the two cushioning inserts to provide stability and achieve a comfortable and high performance cushioning effect. Under conditions repeating those of Figures 3 and 4, the shoe of Figure 5, with fluid communication between the cushioning units, leads to discomfort, instability and possible foot injury. More particularly, when a localized high load area (a rock in this example) is encountered by the shoe outsole **65**, forces are transmitted upward through the cushioning member **67**, leading to upward deflection of the outboard chambers **67a** and **67b**. Because cushioning member **67** is in fluid communication with cushioning member **73**, under applied load, the fluid pressure in all chambers of cushioning members **67** and **73** nearly instantaneously equalize. Chambers **67a** and **67b**, bottom-out and press upwardly against cushioning member **73**. Since there is no load distributing member the cushioning members also thrust upwardly, pressing against the bottom surface of the foot creating a very uncomfortable and painful bulge within the shoe. Chambers **67a** and **67b**, **73a** and **73b**, nearly totally bottom out allowing the pressure of the rock to transmit almost directly into fat pad **71** of the heel of the foot. The fluid communication between the upper and lower cushioning members results in instability characteristic of a single very thick air cushion device and provides an excellent example of a "tennis ball" effect. Furthermore, the outboard cushioning design of both members **67** and **73** fail to provide the distinct comfort associated with the "riding-on-air" feel, characteristic of the inboard positioning of one of the cushioning members.

Accordingly, Figures 3 and 4 evidence how a preferred embodiment functions in a unique, novel, and highly beneficial way over prior art designs. It achieves the best of both worlds, i.e., the "riding-on-air" cushioned comfort, softness, formability and pliancy which is dynamically integrated with the technical and sophisticated world of high impact energy absorption, distribution, storage and efficient dynamic energy return, as well as rear and forefoot stability, motion control, banked track effect when stopping and blocking, injury protection, orthotic support, pronation control, etc.

Figure 6 graphically represents the predicted load versus deflection performance of the subject invention. At a standing load, a relatively low pressure comfort cushioning device (curve "A") undergoes a significant amount of its potential deflection providing a "riding-on-air" feel. As load increases, the comfort cushioning device bottoms out. However, the performance cushioning device (curve "B") is rapidly undergoing deflection, while absorbing, cushioning, distributing, storing the potentially damaging impact force, and eventually returning this otherwise wasted energy to the wearer as a beneficial propulsion force. At maximum load, both the comfort cushioning device and performance cushioning device approach bottoming out. The two cushions functioning together in tandem, spread the impact force over the greatest possible time interval, achieving maximum cushioning. Curve "C" shows the combined and unique synergistic effect of the two cushioning devices.

It is believed that when single air filled cushioning devices exceed 0.800 inches in shoes, instability arises as a result of a "tennis ball" effect. Furthermore, when multiple air chambers are placed one atop the other to achieve a thickness greater than eight hundred thousandths of an inch, instability arises. In contrast, as shown in the current invention, a load distributing device between the upper and lower fluid containing cushioning inserts redistributes forces between the two chambers sufficiently to substantially avoid the "tennis ball" effect and allows the combined thickness of the two inserts to exceed 0.800 inches. Accordingly, cushioning inserts totalling a combined thickness of greater than 0.800 inches would appear to be effective when constructed in accord with the subject invention. As should be apparent to those skilled in the art, this feature significantly improves the cushioning ability of the shoe without a loss in stability.

Figure 7 represents the individual components in the exploded preconstruction stage of a preferred embodiment of the invention. In this embodiment, a sockliner **42** is positioned over an inboard fluid containing multichamber cushioning device **43**. Both are positioned within the shoe upper **44** on top of load distributing element **45** comprised of a mesh, the filaments of which have a high tensile strength such as nylon, polyester, kevlar, fiberglass, metal, etc. which is optionally substituted for

Robus or Texon board or cement reinforced fabric of a "stitch lasted" shoe. This shoe is then laid-up on top of performance fluid containing multichamber cushions **47** and **47a** secured in midsole **49**. In this embodiment, performance cushions **47** and **47a** can be either permanently inflated **(47a)** or may be inflated with a valve **46**. In one construction embodiment, it is envisioned that upper **44** would be secured around a last (not shown) and its fabric or other material sealed at its base by the load distributing element **45**. The outboard performance fluid containing cushioning device is preferably foam encapsulated as an integral part of midsole **49**. The outsole **51** is cemented to the midsole and the resultant product is securely cemented or otherwise attached to the shoe upper comprising the load distributing element. As can be seen, the cushioning devices are generally thicker in the heel area where maximum loading occurs, with the performance cushioning device being thicker than the comfort cushioning device.

Figure 8 illustrates an alternative embodiment of the invention, wherein shoe upper **101** is glued and/or stitched at its lower periphery **103** to an air filled cushion device **105**. Air cushion device **105** is positioned above load distributing element **124**. This air cushion comprises elastomeric layers **126a** and **126b** mechanically bonded with a drop thread linked fabric **128** as described in U.S. Patent No. 4,906,502 and 5,083,361. Additionally, the comfort factor may further be enhanced by the use of a conventional anatomically shaped foam (or equivalent) sock liner **125**. A second performance oriented cushioning device **123** is placed in midsole **113**. Again, cushioning device **123** is foam **121** encapsulated. In this embodiment, calcaneus **107** and fat pad **108** are in elastomeric contact with comfort air cushion **105**. Accordingly, the cushion device actually forms part of the lasted base of the foot enveloping upper. In this design, the cushioning device is functionally positioned inboard, and it remains in uninterrupted cushioning contact with the foot.

In this embodiment of the subject invention, the contiguous board-lasted or stitch lasted components of the shoe upper **103** can perform, at least in part, the function of the load distributing element, positioned between the first and second air cushioning devices **105** and **123**.

The load distributing element(s) function in a key role in the subject invention, setting it apart from prior cushioning endeavors because it separates and isolates, at least in part, the function and load/deflection characteristics of the fluid containing cushioning device(s) positioned within the footwear constraining envelope of the shoe, i.e., the inboard component, from the lower fluid containing cushioning device(s) positioned within the midsole of the shoe, i.e., the outboard component. It is important to recognize that simply positioning one of the cushioning devices above the other cushioning device regardless of their pressurization, will result in an article of footwear having unacceptable dynamic instability similar to standing on a tennis ball if one or more load distributing element(s) is not utilized.

The load distributing element, in its multitude of various designs, shapes and materials, is a particularly important component of the invention, characterizing and distinguishing it from several prior attempts to incorporate liquid or pneumatic type cushions into stacked or nested designs. In some areas, such as directly beneath the calcaneus, it may be desirable to have the inboard and outboard cushioning devices working in part in unison to achieve a more significant deflection under maximum impact loading. Accordingly, the load distributing element may be cut out in the area below the calcaneus, i.e. in a "U"-shaped pattern. Thus, the maximum allowable deflection can be accomplished so as to spread the impact load over the maximum achievable time interval. In this manner, within the overall design constraints, the shoe transmits the lowest possible shock force to the foot, leg, body and head of the wearer. However, the cutout region cannot be so extensive as to result in instability. Moreover, it is believed that at least the periphery of the load distribution element must remain intact to prevent a "tennis ball" effect. In the preferred embodiment, the load distributing element lies under at least 40% and preferably 50% at the foot's heel pad.

Preferably, the load distributing element comprises a flexible, thin and lightweight material which redistributes localized forces laterally across the interface of the two or more cushioning devices. The load distributing element separates and at least partially isolates and maximizes the beneficial features of the upper and lower fluid cushioning devices to optimize comfort, cushioning, and performance and simultaneously prevent localization of forces leading to various undesirable consequences including a foot injury, a "tennis ball" effect and/or an aneurism failure of the pressurized device. Particularly, preferred load distributing elements support at least the heel and metatarsal areas. These areas receive the greatest load and are most prone to injury and bottoming out. Accordingly, forces are more evenly distributed across the cushioning devices and the load distributing element itself may absorb and store some energy. Particularly preferred materials include Robus board, Texon board, a stitch lasted base of the upper, kevlar, metal mesh or fiber reinforced composites or combinations thereof. Certain load distributing elements, such as high modulus of elasticity materials, may also be utilized to provide energy return. A load distributing element suitable for use in this invention is described in U.S. Patents 4,506,460 and 4,486,964, which are herein incorporated by reference. The load distributing element can be of any shape required to redistribute force. In fact, the type of athletic shoe may determine the load distributing element shape. Moreover, tennis shoes may require a greater load distributing element effect in the forefoot and running shoes in the heel. Several exemplary load distributing elements are shown in Figures 9A, 9B, 9C and 9D.

As described herein, forces within the shoe sole are considered normal in the plane of the load distributing element. Nominally vertical forces travel downward from

the foot through the upper cushion to the load distributing element and upward from the outsole through the lower cushion to the load distributing element. The load distributing element distributes forces generally horizontally across the shoe and the two interactive cushioning devices, preventing a "tennis ball" effect. In the case of a "U-shaped" heel load distributing element, interaction occurs locally between the first and second cushioning members in the center of the heel which greatly dissipates the high load force under the calcaneus as a result of a greater deflection and absorption of shock load. Shock forces to the foot, leg, and body are significantly reduced. These designs avoid adding unnecessary weight to the shoe and maximize the interactive and load absorption and distribution nature of the top and bottom units in high impact areas while maintaining stability.

The load distributing element may be comprised of either a low modulus (below about 250,000 psi) material or an intermediate (between about 250,000 and 1,000,000 psi) or high (above about 1,000,000 psi) modulus material or combinations thereof depending on the desired end objective. U.S. Patent Nos. 4,486,964 and 4,506,460 directed to a spring load distributing element/stabilizer device clearly define the benefits of an intermediate and high modulus type of load distributing element. However, it should be noted that conventional shoe components utilized in constructing the shoe upper, and particularly the area supporting the plantar surface of the foot, are equally acceptable and fully functional within the scope of the subject invention, often without any significant modification. Accordingly, the load distributing element of the current invention could comprise, but is not limited to, the board of board lasted shoes, the board of tuck hoard lasted shoes and the reinforced cemented fabric of stitch lasted shoes. In addition, other portions of the shoe which may, depending on shoe construction, lie intermediate the inboard and outboard cushioning components such as, but not limited to, the heel counter, stabilizers, cantilevered support components, may form individually or as combinations of other components, the load distributing element.

It should be recognized that a spring type load distributing element has been shown to add improved stability and provide a significant energy return to the user; for example, the storage and return of impact energy can be as much as 6% more energy efficient than with a shoe structure without a spring load distributing element/air cushion combination. Furthermore, the use of the load distributing element has allowed the construction of air cushioning soles of significant thickness while achieving good to excellent stability. Moreover, a shoe has now been provided with superior comfort, i.e., a "riding-on-air" feel in combination with superior technical performance. Previously, it has been necessary to sacrifice comfort to achieve performance and vice-versa. In addition, the combination of these two fluid filled cushioning devices in combination with the load distributing element has the effect of providing greater cushioning in extreme loading conditions without bottoming out or instability.

In a preferred embodiment of the invention, an inboard cushioning device adjacent the foot has a thickness of less than 0.350 inches, more preferably about 0.250 inches. This requirement is important because movement of the foot within the upper, when exceeding more than one-third of an inch has been found to cause sufficient rubbing between the foot and the heel counter and other sections of the shoe resulting in uncontrolled movement of the foot within the envelope of the article of footwear and blistering, irritation and abrasion of the foot surface. For optimum performance during high impact athletic endeavors, the outboard cushioning device below the load distributing element will preferably have a thickness of at least 0.400 inches, more preferably greater than 0.750 inches.

When a compressible fluid is utilized the cushioning device adjacent the foot is preferably pressurized to between greater than 0 and 20 pounds per square inch as defined by gage pressure and the cushioning device below the load distributing element is pressurized to a gage pressure of between about 5 and 50 pounds per square inch. The 0 and 20 pounds of pressure provides a soft feel to the foot, i.e. a highly resilient cushion. The 5 to 50 pounds of pressure in the device below the load distributing element absorbs, distributes, stores, and returns potentially damaging and otherwise wasted impact energy in an energy efficient manner during walking, running and jumping. Accordingly, in a preferred embodiment, the shoe is provided with a "softer" cushioning device adjacent the foot to provide comfort, i.e. "riding-on-air", while the cushioning device adjacent the ground has a higher pressure and generally a greater thickness, providing high impact absorbance and stability for an athletic shoe. The phrase "riding-on-air" is appropriate because a preferred cushioning device is pressurized with a compressible fluid such as gas or air. When an incompressible fluid is utilized, the cushion members are not required to be pressurized. Preferably, the elastomeric cushioning device is filled to about 0 p.s.i.g.

In addition, the inventive shoe design facilitates customizing, optimizing and tailoring of the shoes comfort and performance characteristics. Moreover, the cushioning device adjacent the foot can be designed to have a lower pressure than the cushioning device adjacent the ground. In fact, the lower pressure comfort cushion adjacent the foot can be manufactured in a range of pressures and combined with a high pressure performance cushion having its own range of pressures to provide a shoe with a great diversity of applications, tailoring the shoes capabilities for different sports and sex or weight of the wearer.

As will be apparent to one of ordinary skill in the art, certain designs may incorporate the cushioning device adjacent the foot into the sock liner of the shoe. The cushioning device below the load distributing element can be comprised of one or several foam encapsulated multichamber units, a single chamber non-foam encapsu-

lated unit or a combination thereof, i.e. foam encapsulation is not required.

Thus, it is apparent that there has been provided, in accordance with the invention, an article of footwear that fully satisfies the objects, aims and advantages set forth above. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations would be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the appended claims.

Some aspects of the invention are as follows: An article of footwear includes one or more first fluid containing cushion devices in direct or elastomeric load transmitting contact with a foot to provide superior comfort. One or more second, preferably thicker, fluid containing cushion devices are positioned in a load transmitting portion of the sole, between the foot and ground engaging surface of the footwear. The first cushion device(s) at least partially overlap a portion of the second cushioning device(s) and the two cushion devices are at least partially separated in any overlapping areas by a load distributing element.

Claims

1. An article of footwear comprising an upper shaped to envelop a foot and a sole secured to said upper, said sole having at least a ground engaging portion,

   a first sealed barrier member of elastomeric material containing a fluid positioned between at least a portion of said foot and said ground engaging portion of said sole,

   a second sealed barrier member of elastomeric material containing a fluid positioned between at least a portion of said foot and said ground engaging portion of said sole, said first sealed member at least partially overlapping said second sealed member, and

   a load distributing element to redistribute forces located between at least a portion of said overlapping region of said first and second members.

2. The article of claim 1, wherein said elastomeric material of said first and second members is comprised of polyurethane.

3. The article of claim 1, wherein said first member is further comprised of a plurality of interconnecting chambers.

4. The article of claim 1, wherein said first member is positioned only under a portion of said foot.

5. The article of claim 1, wherein the fluid in at least one of said members is compressible.

6. The article of claim 1, wherein the fluid in at least one of said members is incompressible.

7. The article of claim 5, wherein said first member has a gage pressure of between 0 and 20 psi and said second member has a gage pressure of between about 15 and 50 psi.

8. The article of claim 5, wherein the fluid in at least one of said members comprises a mixture of air and a gas selected from the group consisting of hexafluoroethane; sulfur hexafluoride; perfluoro propane; perfluorobutane; perfluoropentane; perfluorohexane; perfluoroheptane; octafluorocyclobutane; perfluorocylobutane; hexafluoropropylene; tetrafluoromethane; monochloropentafluoro-ethane; 1,2-dichlorotetra-fluoroethane; 1,1,2-trichloro-1,2,2-trifluoroethane; chlorotrifluoroethylene; bromotrifluoromethane; and monochlorotrifluoromethane and mixtures thereof.

9. The article of claim 1, wherein said load distributing element is comprised of a flexible and resilient material.

10. A structure adapted to form part of a shoe comprising a first fluid containing cushioning device at a first pressure, said first device in a load transmitting position intermediate a foot and a ground engaging portion of said shoe, a second fluid containing cushioning device at a second and higher pressure, said second device in a load transmitting position intermediate at least a portion of said first device and a ground engaging portion of said shoe, a load distributing element to redistribute force in a load transmitting position intermediate at least a portion of the load transmitting area intermediate said first and second devices.

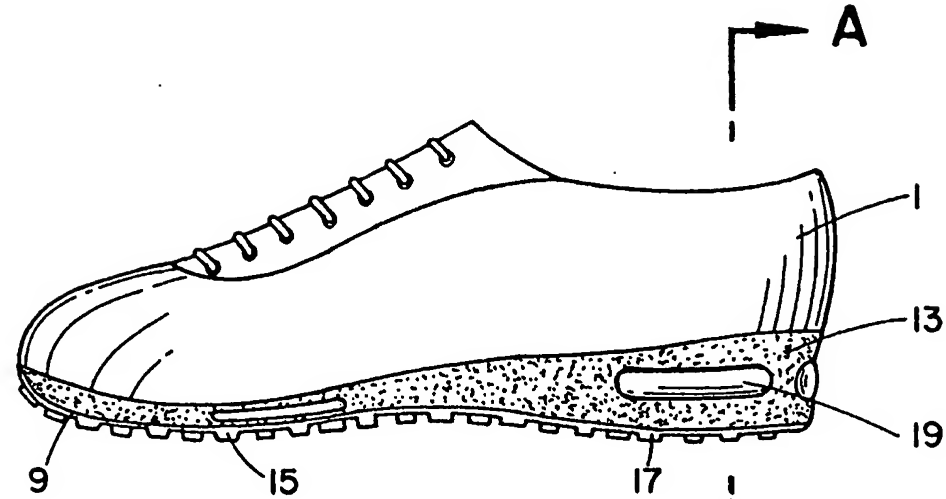


FIG. 1

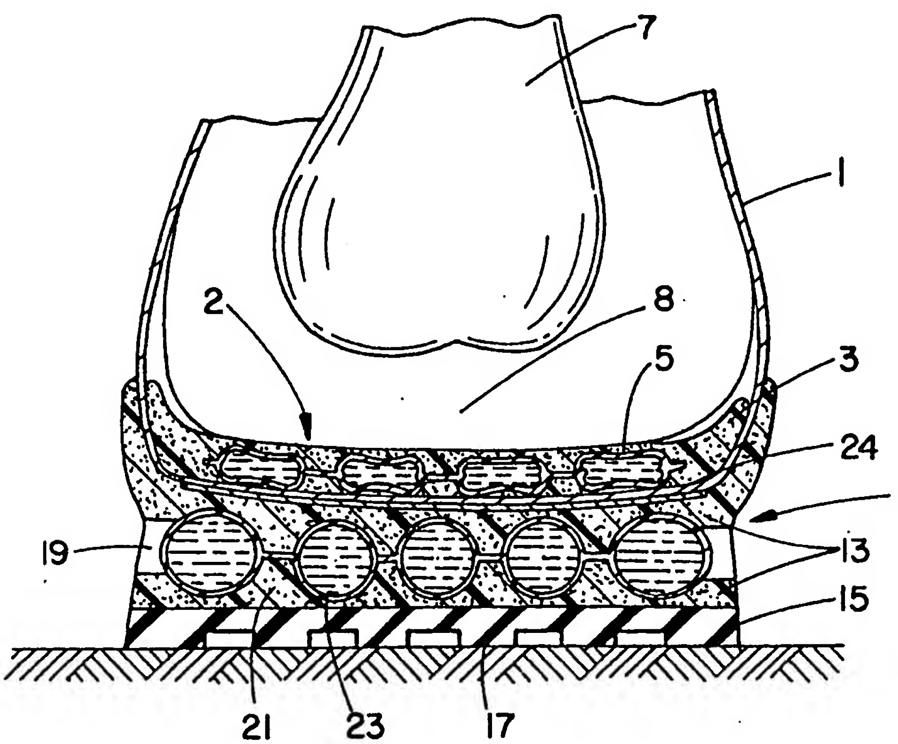


FIG. 2

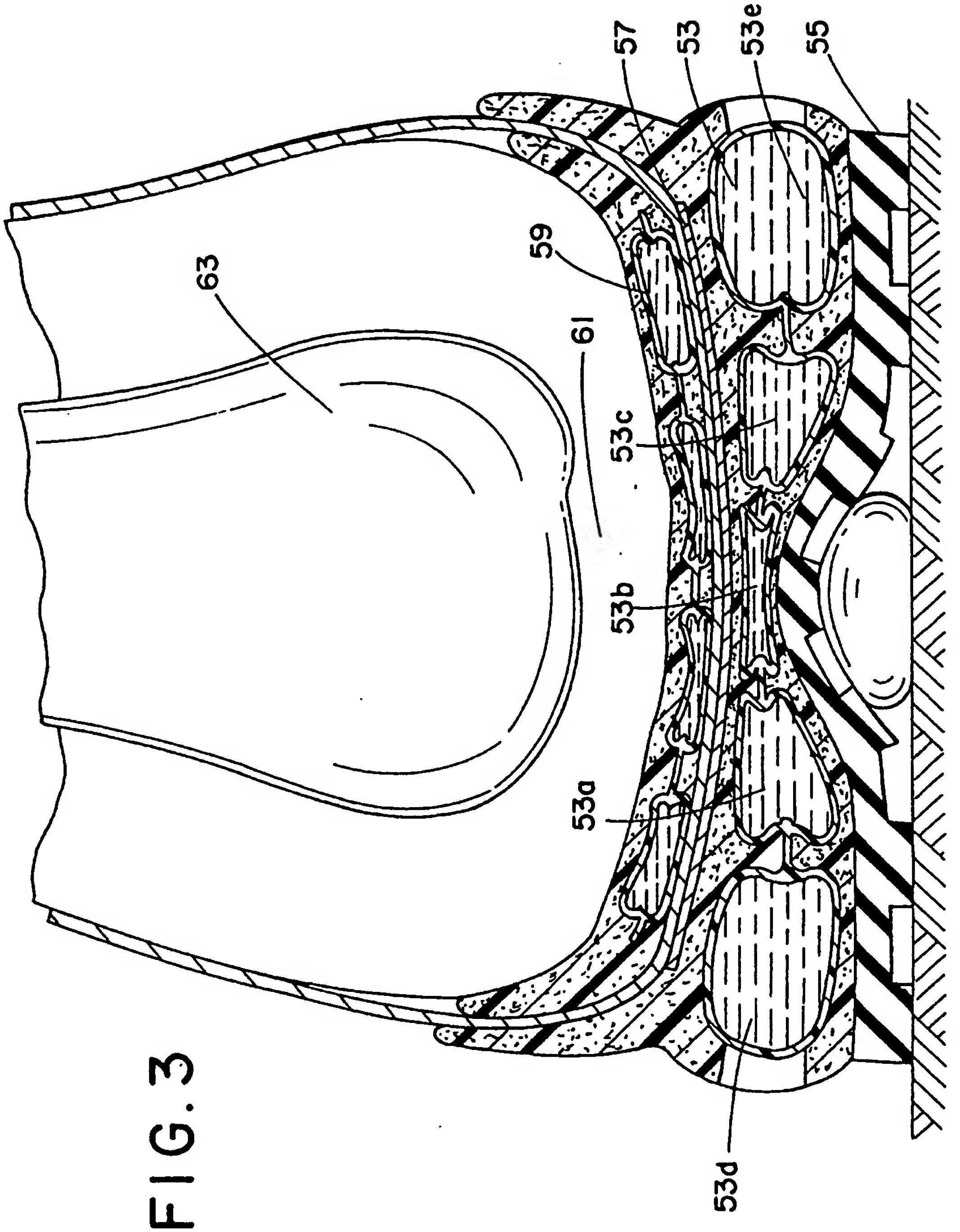


FIG. 3

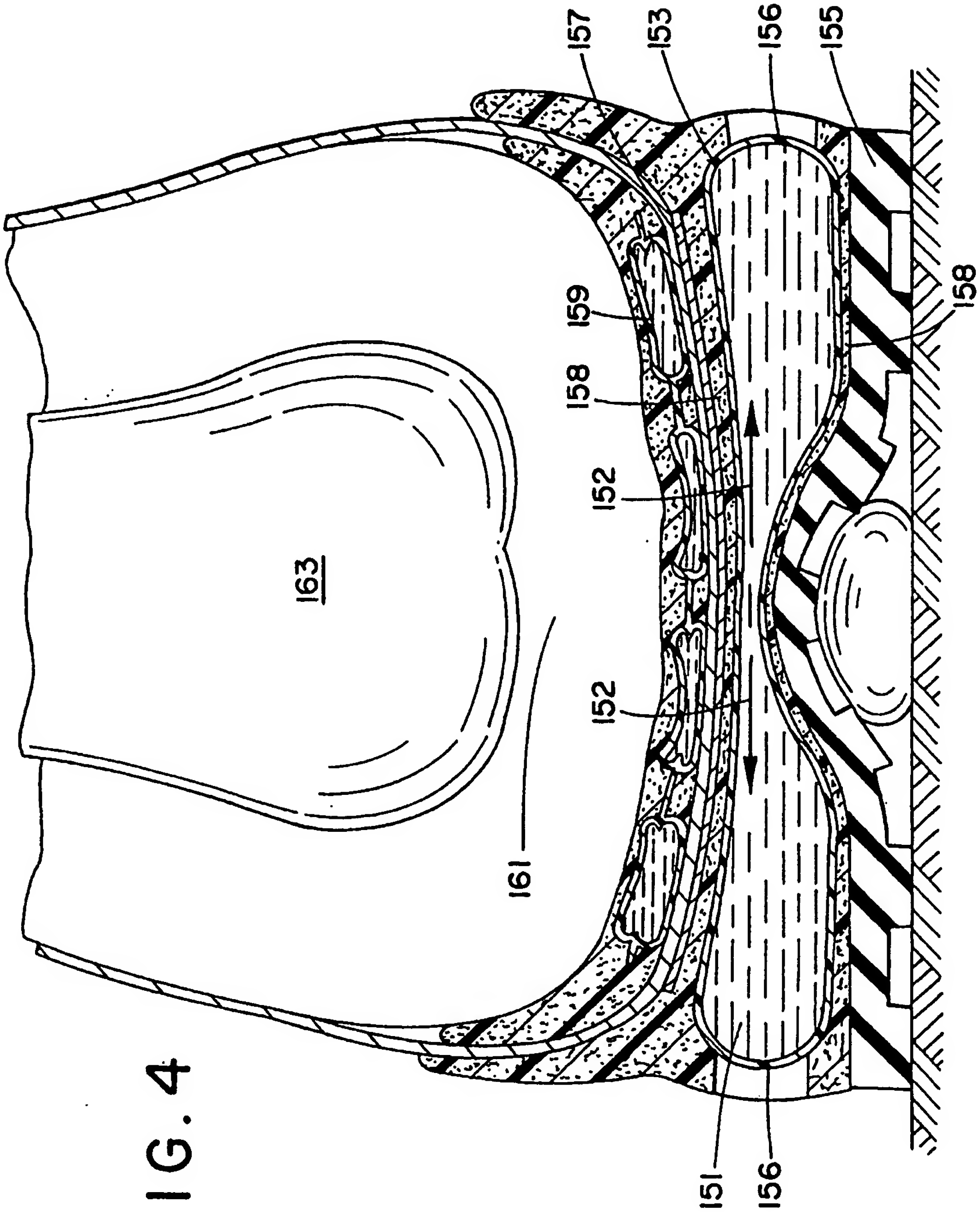


FIG. 4

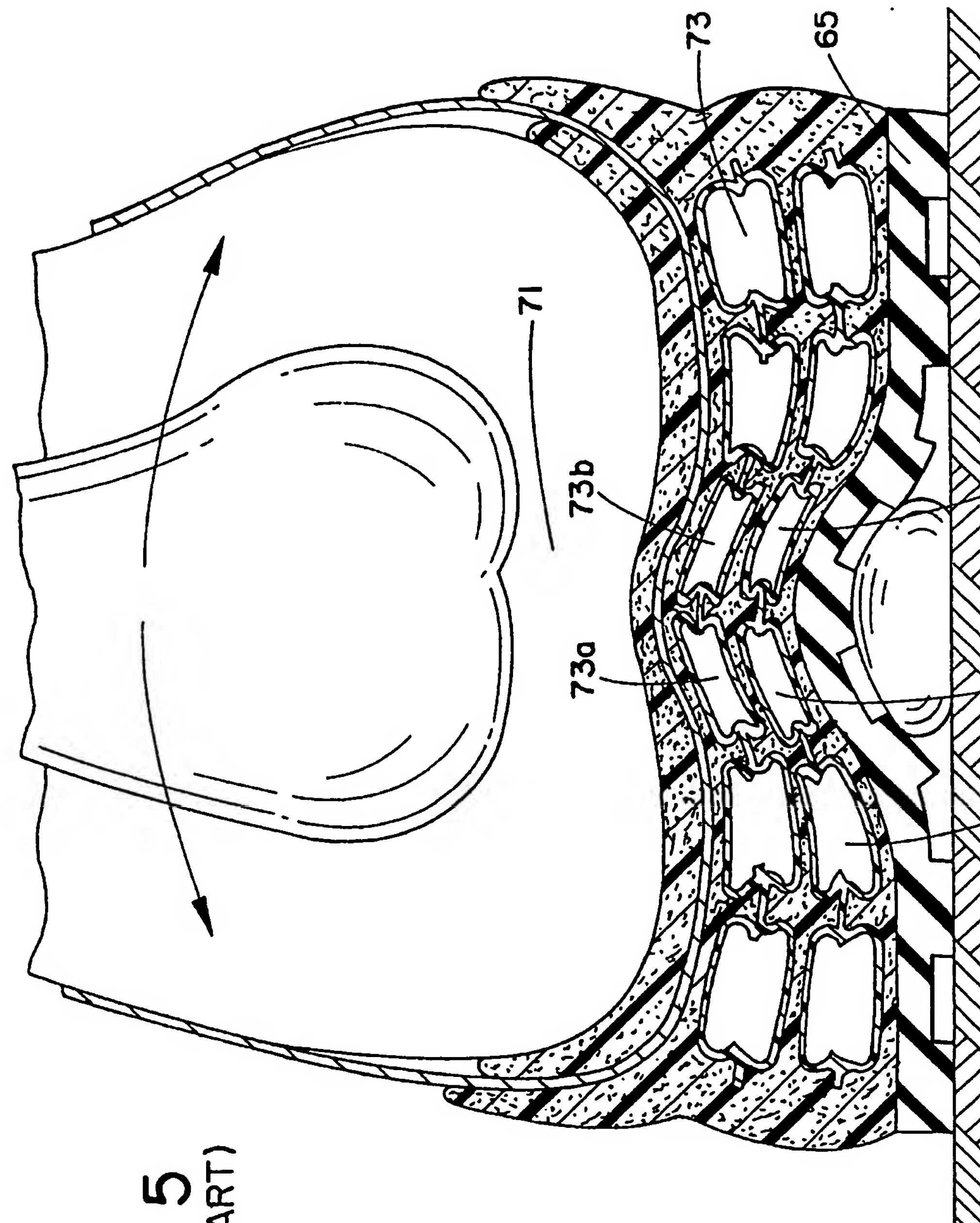


FIG. 5
(PRIOR ART)

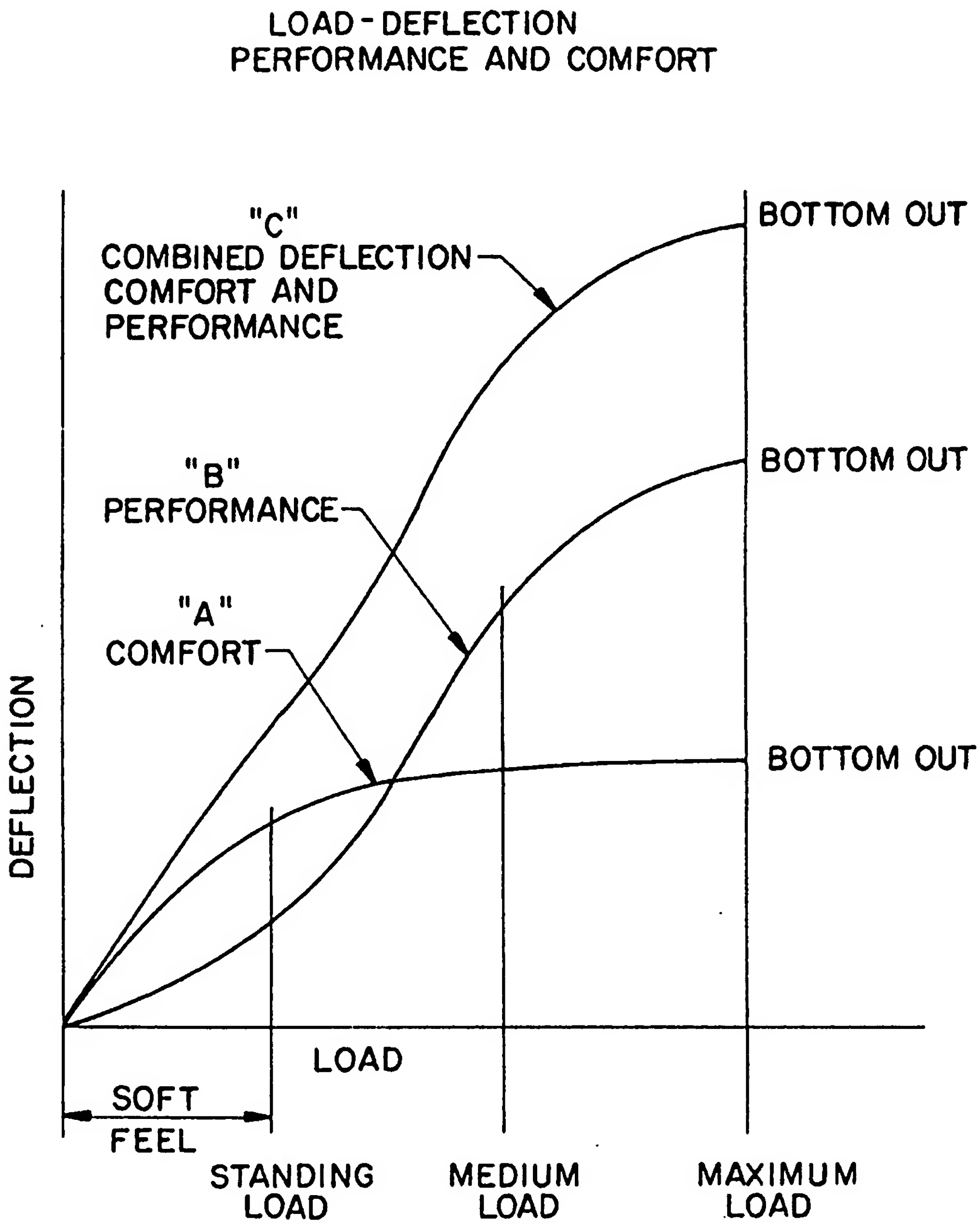
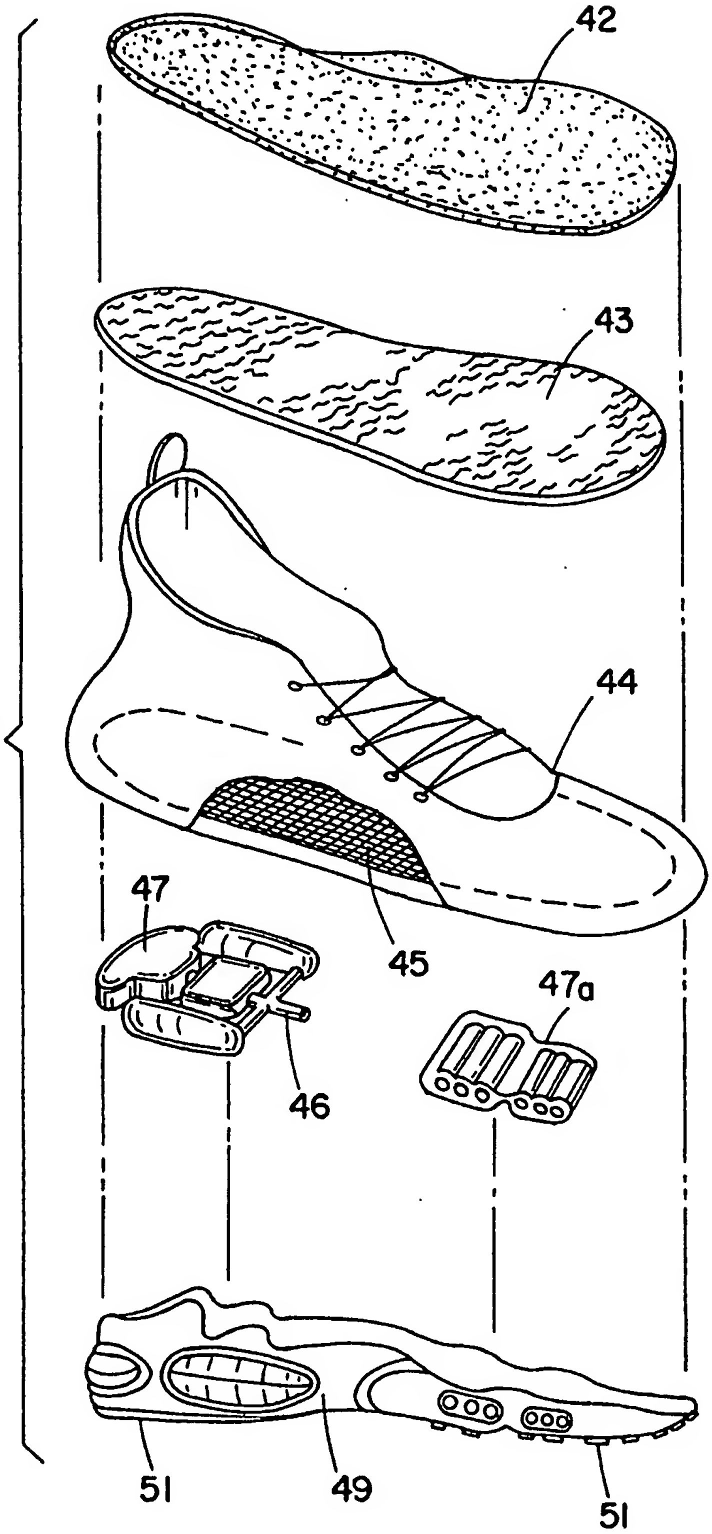

LOAD - DEFLECTION
PERFORMANCE AND COMFORT
"C"
COMBINED DEFLECTION
COMFORT AND
PERFORMANCE
"B"
PERFORMANCE
"A"
COMFORT
BOTTOM OUT
BOTTOM OUT
BOTTOM OUT
DEFLECTION
LOAD
SOFT
FEEL
STANDING
LOAD
MEDIUM
LOAD
MAXIMUM
LOAD

FIG. 6

FIG.7



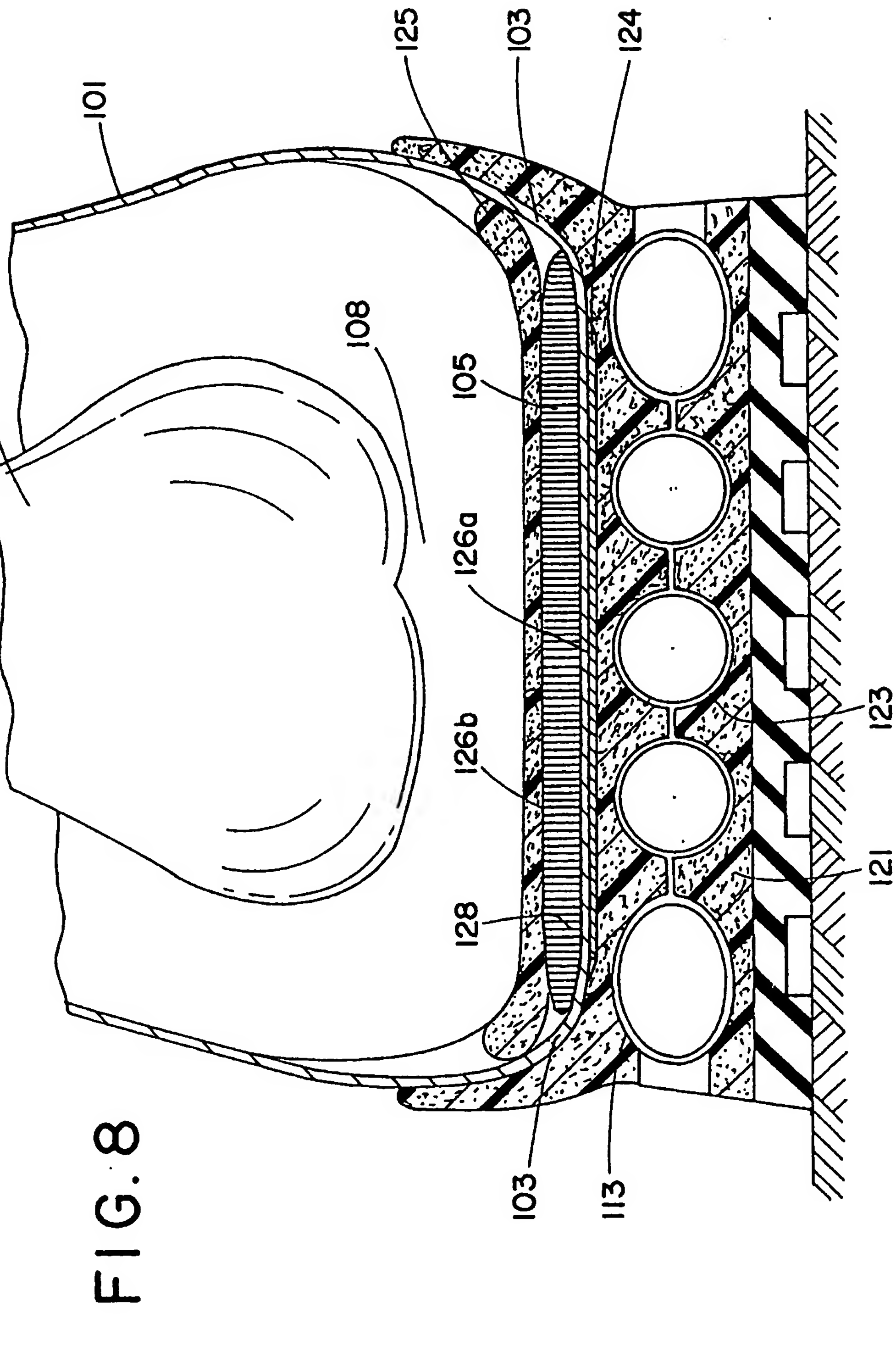


FIG. 8

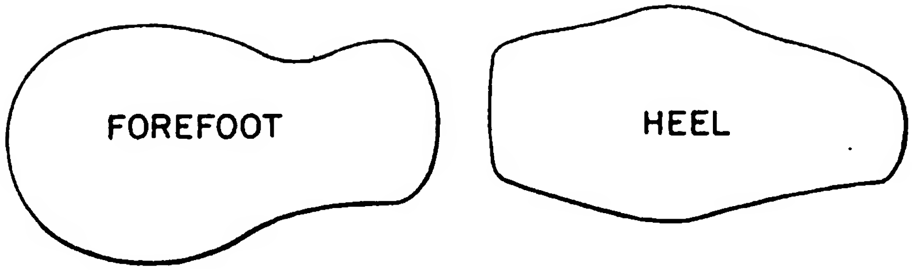


FIG. 9A

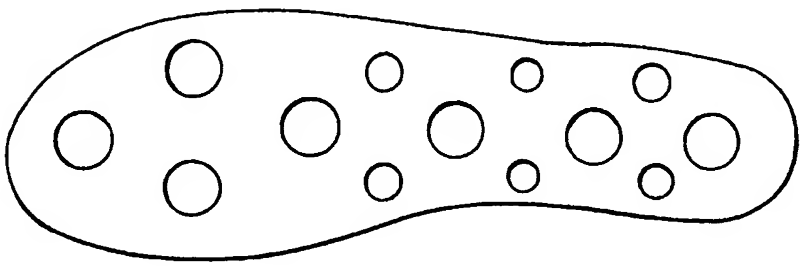


FIG. 9B

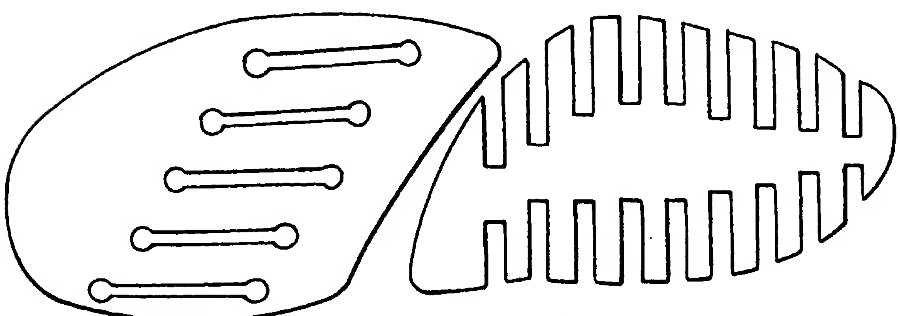


FIG. 9C

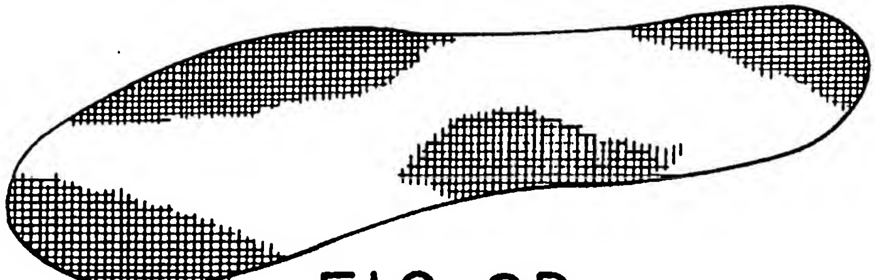


FIG. 9D